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Brussels Institute of Contemporary China Studies

29. March 2013

Asia Paper ● Volume 7 ● Issue 2 ● 29 March 2013 ● ISSN 2034 5364

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Abstract. The US financial crisis and subsequent European sovereign debt crisis not only constitute serious threats to the security of China's foreign exchange reserves, but also provide an advantageous opportunity for China to change its ideas on foreign exchange reserve management. First, according to rules of thumb, the authors assess the optimal size of China's foreign exchange reserves in terms of short-term external debt, imports and domestic liquid assets. Second, the paper estimates the asset structure of China's foreign reserves based on the statistics on China's holding of US and Japanese securities. Third, the authors calculate the People's Bank of China sterilization costs from the perspective of issuing central bank notes and raising required reserve ratios. Fourth, the paper measures the total and net investment yield of China's foreign reserves in terms of nominal dollars, real dollars (dollar index) and nominal renminbi. Finally, the authors put forward suggestions on how to accelerate the diversification of China's international reserves. *Keywords:* International financial crisis, Foreign exchange reserves, Management, Diversification.

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Series editor: Jonathan Holslag.
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www.vub.ac.be/biccs

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CHINA HAS accumulated huge foreign exchange reserves, with an unprecedented total of about USD 3.3 trillion in 2012, as a result of a large and persistent trade surplus and foreign direct investment inflows over more than a decade. It is widely recognized that more than 60 percent of these reserves have been invested in US Treasury and agency bonds, traditionally the world's safe-haven location. At the end of June 2011, China held USD 1.3 trillion of US Treasury securities, making it the largest creditor to the world's largest economy. The international financial crisis originating in the US and current European sovereign debt crisis have constituted major threats to the security of China's foreign exchange assets. A combination of the US's exceptionally loose monetary policy, particularly the fresh round of quantitative easing of the Fed (QE3) beginning in September 2012, and the downgrading of euro-zone sovereign credit ratings, has placed pressure on China's monetary authority to accelerate the diversification of its huge foreign exchange reserves from US government debt securities. As a relatively poor developing country, China is facing a problem virtually unique in history: it has too much money, and doesn't know what to do with it, which is totally opposite to its rich western partners: they have too much debt, and don't know how to reduce it. Put differently, while the US and the euro zone are facing a sovereign debt crisis, China is facing a sovereign asset crisis.

The substantial rise in the risk of non-sustainability of its sovereign debt, unceasing quarrels about the federal government debt ceiling, low political willingness to reduce public debt and the debt monetization (quantitative easing) monetary policy in the US, and especially the cut in the nation's hallowed AAA rating by credit rating agency Standard & Poor's to a mere AA+ on 5 August 2011, greatly shook the confidence of China's monetary authority in the security of US government debt securities. Ironically, the immediate impact of the US sovereign credit downgrade was a rebound in US Treasuries, due to the "flight to quality" effect. However, the sovereign credit downgrade has underlined the risk of holding US dollar assets, and the third round of quantitative easing has served only to leave China more exposed to foreign exchange rate risk of its dollar-denominated assets.

Obviously, a practical choice for China's monetary authority would be to significantly diversify from its exposure to the US dollar, and substantially increase its holdings of non-dollar assets: euro-denominated government bonds and Japanese government bonds (JGBs). In recent years, China has raised its exposure to Japanese yen and euro government debt securities, even though the euro zone is suffering from a sovereign debt crisis.

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According to the Bank of Japan, the net total purchase amount of JGBs by China was JPY 14.5 trillion (USD 188.7 billion) in 2010 and 2011, which is 4.26 times as large as the outstanding amount in 2009. China's rapidly increased holdings of JGBs could be owing to the substantial narrowing of yields between US and Japanese government bonds, and the strong appreciation of the yen versus the dollar.

As part of the strategy to bolster the EU economy and to diversify away from over-investment in US government debt securities, China has continuously increased purchase of Eurobonds despite the European debt crisis. China has expressed its willingness to invest in the euro area bailout bonds (EFSF bonds) many times, although the quantity that it has actually purchased is possibly limited due to the unclear future of euro zone fiscal consolidation. According to news reports, China has purchased several billion euros-worth of bonds sold by Greece and Portugal, and China might embark on another round of purchase of sovereign debt in the euro area, although such reports are unconfirmed. In April 2011, China already held €25 billion (USD 36.3 billion) of Spanish sovereign debt, up from €6 billion in 2009, and which represents the equivalent of 12.5 percent of Spanish debt in foreign hands. Yet, following the development of the European sovereign debt crisis, these investments may not look safe either. In addition to the substantial rise in sovereign default risk in the southern euro members heavily affected by the crisis, China's euro assets also faced large foreign exchange rate risk in 2010 and 2011, with a depreciation of around 10 percent of the euro versus the dollar, and even more against the renminbi (RMB).

In the context of the international financial and sovereign debt crisis, it is critically important to estimate the benefits and costs of China's foreign exchange reserves, and put forward some policy suggestions on how to accelerate the diversification of Chinese huge international reserves. The rest of the paper is organized as follows. Section two roughly assesses the optimal size of China's foreign exchange reserves in terms of short-term external debt, imports and domestic liquid assets. Section three presents an evolution path of the currency and securities structure of China's foreign reserves during the past decade. Section four provides an estimate of the sterilization costs of the People's Bank of China's (PBOC) foreign exchange reserve holdings from the perspective of issuing central bank bills (CBBs) and raising the statutory reserve requirement ratio of banks. Section five estimates the gross and net revenue of China's foreign reserves over the period from 2002 to 2011, in terms of nominal dollars, real dollars (dollar index) and nominal RMB. Section six presents concluding remarks and puts forward some policy implications.

1. Optimal Size of China's Foreign Exchange Reserves

As we know, foreign exchange reserves can play a vitally important role in reducing the risks of external debt and local currency crises, and mitigating the negative shocks of a sudden reduction of capital inflow or capital flight when a financial crisis occurs. Adequate foreign exchange reserves can provide monetary authorities broad space to adjust macroeconomic policy and enhance investors' confidence in the ability of a country to meet external obligations. Owing to the buffer of huge foreign exchange reserves, China's cross-border capital movements have been quite stable during the US financial crisis and European debt crisis.[1] Chinese experience highlights the importance of a foreign reserve

buffer for those countries that suffer persistent current account deficits, lack international capital market access, or are burdened with large short-term external debt.

There are some commonly used rules of thumb to measure foreign exchange reserves adequacy for emerging market countries. One traditional benchmark is whether there are enough reserves to cover three months of imports. Alternatively, the widely cited Greenspan-Guidotti rule stipulates that 100 percent coverage of short-term external debt is adequate. Wijnholds and Kapteyn[2] have proposed adding 20 percent of M2 to the benchmarks, since broad money can be used to represent the stock of liquid domestic assets that could be sold and transferred into foreign assets during a crisis. Recently, the IMF has proposed a benchmark that combines short-term debt, other portfolio liabilities, M2, and exports as indicators.[3] In sum, three indicators of reserves adequacy have been widely recognized and commonly used: the ratio of (i) official reserves to imports, (ii) reserves to broad money, and (iii) reserves to short-term external debt.

Based on the above rules of thumb, we make a rough estimate of the optimal size of China's foreign exchange reserves. In consideration of China's generally effective capital controls and stated-owned-bank-dominated financial system, capital flight risk in China should be significantly lower than other emerging economies with small foreign exchange reserves and loose capital controls. Hence, the weight given to M2 for China could be reduced where effective capital controls are in place that would prevent capital flight. Borrowing from the IMF in 2011, we add 5 percent rather than 20 percent of M2 to the traditional measure indicators of three months imports and short-term external debt. Table 1 presents our estimate of the optimal level of China's foreign exchange reserve.

With the rapid rise in the amount of imports, short-term external debt and M2, the optimal size of China's foreign reserve has increased substantially in the past ten years. Even so, since 2002 the amount of China's foreign exchange reserves has surpassed the optimal size. Furthermore, the gap between actual and optimal reserves has grown continuously since 2002. In 2011, the optimal size of China's foreign reserves was a record USD 1.547 trillion, but the scale of excessive reserves was likewise at its highest level of USD 1.634 trillion. Hence, how to invest the huge excessive foreign reserves has become the most challenging task that China's monetary authorities face.

	Short-term external debt	Three months' imports	5 percent of M2	Optimal reserve size	Excess reserve size
2001	84	61	88	233	-21
2002	87	74	104	265	22
2003	103	103	123	329	75
2004	139	140	143	422	188
2005	172	165	168	505	314
2006	199	198	202	599	467
2007	236	239	246	721	807
2008	226	283	316	825	1121
2009	259	251	396	906	1493
2010	376	349	492	1217	1631
2011	501	436	610	1547	1634

Table 1. The Optimal and Excessive Size of China's Foreign Exchange Reserves (USD billion)
Source: CEIC.

2. Currency Structure of China's Foreign Exchange Reserves

Now, there are no publicly released data on the currency structure of China's foreign exchange reserves. However, it is widely recognized that Chinese international reserve assets are predominantly allocated into three main international currencies: dollar, euro and yen. We can obtain information on the value of China's holding of US and Japanese securities from the US Treasury International Capital (TIC) reporting system and the Bank of Japan respectively. Hence, we can undertake an approximate estimate of the currency structure of China's foreign exchange reserves.

As Table 2 shows, the size of China's holdings of US securities has undergone dramatic growth in the past decade, rising from USD 181 billion in June 2002 to USD 1.727 trillion in June 2011. China was the largest holder of US Treasury securities in June 2011, with total holdings of USD1,307 billion, an increase of USD195 billion from June 2010. The share of China's holding of US Treasury securities in the total foreign holdings grew from 8 percent in March 2000 to 25.9 percent in June 2011. One result of this is that for China the US Treasury bond market may become an illiquid market, because a meaningful reduction of holdings by China could produce significant negative impacts on the prices of the US Treasury securities. This means that China's foreign exchange reserves have reached a non-economic scale. Also, China's huge demand for US Treasury securities helped to maintain their yields at historically low levels in recent years.

	Total	Equity	Long-term debts					Short-term debts		
			Treasury	Agency	ABS	Corporate	ABS	Treasury	Agency	Corp-orate
2002	181	4	95	59		11		1	11	0
2003	255	2	147	91		12		0	3	0
2004	341	3	189	115	15	16	6	5	13	0
2005	527	3	277	172	56	36	7	21	18	1
2006	699	4	364	255	107	59	15	8	8	1
2007	922	29	467	376	206	28	11	11	11	1
2008	1205	100	522	527	369	26	7	13	17	0
2009	1464	78	757	454	358	15	2	159	0	1
2010	1611	127	1108	360	298	11	2	4	0	1
2011	1727	159	1302	245	218	16	2	5	0	0

Table 2. Value of China's holdings of US Securities (End of June, USD billion). *Source:* Report on Foreign Portfolio Holdings of US Securities (Various Issues). Note: ABS (asset-backed securities) can be split into those backed by pools of residential home mortgages and commercial mortgages (MBS) and those backed by other types of assets, such as pools

of credit card receivables, automobile loans, or student loans. Most agency ABS are backed by pools of residential home mortgages.

During the period between June 2002 and June 2011, China's foreign exchange reserves have been primarily invested in long-term US Treasury and agency securities, and their average share of China's dollar securities reached 88.3 percent. This term structure makes China's foreign exchange reserves highly subject to interest rate risk and inflation risk. Owing to its pursuit of higher yields, the PBOC had increasingly purchased agency bonds in the years before the financial turmoil in 2008, and China's holdings of agency securities grew from USD 70 billion in June 2002 to USD 544 billion in June 2008. Because of concerns about default risk of Freddie Mac and Fannie Mae, the PBOC has sold more than half of its holdings of agency securities since the start of the US financial crisis, and agency debt holdings were reduced to USD 245 billion in June 2011, 45 percent of the peak level in June 2008, showing that China's foreign exchange reserve management has had procyclical attributes during the financial crisis[4].

China generally holds very few short-term US Treasury securities, with an average share of 3.6 percent over the period from June 2002 to June 2011. However, China's investment behavior for US short-term Treasury notes has experienced a sharp shift since the US financial crisis. As a result of concern about the inflationary effects of the Fed's quantitative easing monetary policy, China increasingly purchased US Treasury bills, and its holding grew rapidly from USD 13 billion in June 2008 to USD 159 billion in June 2009. But between the June 2009 and June 2010 surveys, China's holding of US Treasury bills substantially decreased to USD 5 billion, which might be attributed to the nearly zero interest rates of US short-term Treasury securities.

	Total	Equity	Debt		
				Long-and -middle-term	Short-term
2002	7.2	0.0	7.2	7.2	0.0
2003	7.9	0.0	7.9	7.8	0.1
2004	12.6	0.0	12.5	12.5	0.0
2005	17.1	0.1	17.1	17.1	0.0
2006	25.2	5.1	20.1	18.1	2.1
2007	40.5	16.1	24.4	24.1	0.2
2008	45.8	14.1	31.8	31.7	0.0
2009	36.6	0.1	36.5	35.7	0.8
2010	157.7	38.2	119.5	46.6	72.9
2011	270.0	44.8	225.2	71.0	154.2

Table 3. Value of China's holdings of Japanese Securities (End of Year, USD billion). *Source:* Bank of Japan.

Table 3 shows the size of China's holding of Japanese securities. Because of the effectively zero interest rates in Japan, China generally held a small amount of Japanese securities before the financial crisis. During the recent US financial crisis and European sovereign debt crisis, Japan has shown the characteristics of a fundamentally healthy financial and economic system, which has substantially increased the pressure for appreciation on the Japanese yen. Motivated by arbitraging the yen appreciation, the Chinese monetary authorities have increasingly purchased Japanese government bonds since 2009. The size of China's holding of Japanese government debt securities rose sharply from USD 36.5 billion in 2009, to USD 119.5 billion in 2010, and USD 225.2 billion in 2011.

Based on the above information on China's holdings of US and Japanese securities, we can roughly estimate the currency structure of Chinese foreign reserves. Figure 1 presents the dollar, euro and yen structure of China's foreign exchange reserves. During the period from 2002 to 2011, the average shares of dollar, euro and yen assets of China's foreign reserves were around 60.6 percent, 36.2 percent and 3.2 percent respectively. The recent financial crisis accelerated the diversification of China's international reserves, and the share of dollar assets fell from 61.0 percent in 2009 to 56.6 percent in 2010, and to 54.3 percent in 2011, while that of yen assets grew significantly from 1.5 percent in 2009 to 5.5 percent in 2010, and to 8.5 percent in 2011. The share of euro assets grew gradually after the crisis began, but declined slightly again in 2011, The European sovereign debt crisis has not produced a significant reduction in the share of China's holding of euro assets, but it may have discouraged any increase.

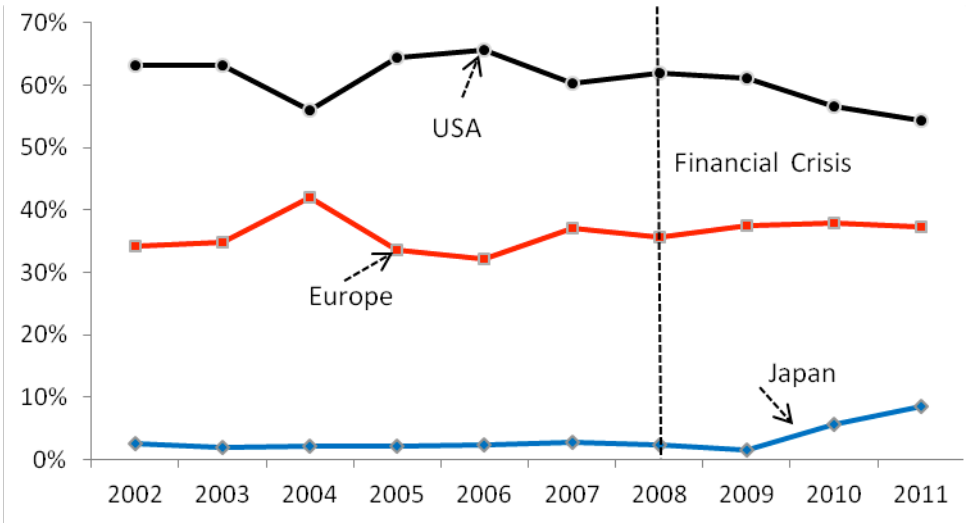

Figure 1. Estimated Currency Structure of China's Foreign Exchange Reserves. *Source:* Authors' Calculation.

It is worth noting that the TIC reporting system possibly underestimates the scale of China's holding of US securities. The reasons are the following: Firstly, the involvement of chains of intermediaries in the custody or management of securities frequently makes accurate identification of the actual owners of US securities impossible. This practice tends

to create a ‘‘custodial bias’’ in the liabilities surveys by attributing excessively large holdings to countries that are major custodial, investment management, or security depository centers, such as Belgium, the Cayman Islands, Luxembourg, and Switzerland. Secondly, an additional problem is caused by bearer or unregistered securities. Because no information is usually available on the ownership of these securities, they are listed in surveys as ‘‘country unknown.’’ Finally, the problem of country attribution occurs in reporting of monthly transaction data. The monthly transaction data record purchases and sales against the country from which transactions are made, which is not necessarily the country of the ultimate purchaser or actual seller or the country of issuance. As transactions tend to be concentrated in major international financial centers, such as the UK and the Cayman Islands, the monthly data show a significant financial centre ‘‘transactions bias’’ that often gives an inaccurate picture of the nationality of the actual foreign buyers and sellers.[5]

3. Sterilization Cost of the PBOC's Foreign Exchange Reserves Holdings

China's huge holdings of foreign exchange reserves has produced some unavoidably high costs, such as, quasi-fiscal cost (yields of foreign exchange reserves less than interest rates of sterilized bonds), opportunity cost (yields of foreign exchange reserves substantially less than those of domestic fixed capital investment, or costs of international lending), financial repression cost (highly regulated and repressed bank system resulting from demands of China's massive sterilization activities) and resultant resource allocation inefficiency (the majority of bank lending is allocated to the inefficient state-owned sector), and economic structure distortion cost (over expansion of the export sector leads to China's overdependence on external sectors and an imbalance of between the internal and external economy).

In this section, we will focus on the sterilization cost of the PBOC's foreign exchange reserve holdings. Following the sharp rise of China's foreign exchange reserves, Chinese monetary authorities have undertaken unprecedentedly massive sterilization operations to neutralize the impacts of foreign exchange market intervention on domestic money supply, such as, open market operations, statutory reserve requirements and bank loan quotas. Currently, the two main sterilization instruments of the PBOC are issuing CBBs and raising reserve requirements. The PBOC needs to pay interest rate costs for CBBs and commercial banks' statutorily required deposits, and which constitutes a quasi-fiscal cost to the PBOC.

Owing to the lack of Treasury bonds to conduct sterilization operations, the PBOC started to issue CBBs in June 2002. However, the high interest rate cost and the underdeveloped capital market hindered the large-scale use of CBBs in China. From the perspective of the PBOC, a great advantage of the statutory reserve requirement instrument is that its interest rate cost is much lower than that of CBBs, even though the finance repression effect is also obvious. To reduce sterilization costs, the Chinese monetary authorities have frequently raised reserve requirement ratios in recent years, with the statutory ratio rising from 6 percent in September 2003 to 20 percent in May 2012. Correspondingly, the importance of CBBs has steadily decreased since 2008, and the outstanding value of CBBs fell from the peak RMB 4.3 trillion in 2008 to RMB 2.3 trillion in 2011.

	Yields of central bank bills (CBBs)				Interest rate of statutory reserve deposit	Average yield of CBBs and statutory reserve deposit
	3 months	6 months	1 Year	3 years		
2002	2.20	2.11	2.08	--	1.91	0.97
2003	2.38	2.45	2.36	--	1.89	2.03
2004	2.66	2.45	3.02	4.14	1.89	2.28
2005	1.47	2.31	2.12	3.42	1.89	1.98
2006	2.13	2.25	2.30	--	1.89	2.05
2007	2.81	--	3.19	3.64	1.89	2.38
2008	3.15	3.69	4.05	4.56	1.85	2.57
2009	1.03	--	1.72	--	1.62	1.50
2010	1.56	--	2.07	2.73	1.62	1.70
2011	2.97	--	3.37	3.90	1.62	1.47

Table 4. Sterilization Cost of Holding Foreign Exchange Reserve of PBOC (Percent)

Source: CEIC and Authors' Calculation.

Therefore, the sterilization cost of the PBOC's foreign exchange reserve holding, namely, the weighted average interest rates of CBBs and statutory reserve deposits can be expressed as

$$C_t = \gamma_{b,t}\left(\sum_i \beta_{i,t} r^i_{b,t}\right) + \gamma_{r,t} r_{r,t}$$

Where γ_b, γ_r represents the share of outstanding amount of CBBs, adjusted incremental amount of statutory reserve deposit in the incremental foreign exchange reserve since 2002 respectively, β_i is the issuance share of three months, six months, one year, and three years term CBBs respectively, r^i_b is the yield of the above four kinds term CBBs, and r_r is the interest rate of statutory reserve deposit.

Owing to the expanding issuance size of CBBs and rising domestic interest rates, the sterilization cost of Chinese monetary authority increased over the period from 2002 to 2008. The average yields of CBBs rose from 2.13 percent in 2002 to 3.86 percent in 2008, and sterilization costs (weighted average yields of CBBs and reserve deposits) rose

correspondingly from 0.93 percent to 2.57 percent (Table 4). Over the period from 2009 and 2010, following the sharp fall of policy interest rates (including statutory reserve deposit interest rates) and the outstanding amount of CBBs, the average sterilization cost substantially declined to 1.75 percent. As a result of the increasing use of the statutory reserve deposit ratio instrument and the substantial decline in the issuance of CBBs, the sterilization cost of the Chinese monetary authorities further decreased from 1.70 percent in 2010 to 1.47 in 2011, although the yield of CBBs rose from 2.1 percent in 2010 to 3.4 percent in 2011. Hence, Chinese monetary authorities' sterilization cost is generally under control, but at the price of financial repression and economic structure distortion.

4. Revenue of the PBOC's Foreign Exchange Reserves Holdings

In this section, we will roughly estimate gross and net investment revenue of China's foreign exchange reserves over the period from 2002 to 2011. The calculation includes three steps: firstly, making full use of all information sources and estimating the currency and securities structure of China's foreign exchange reserves; secondly, based on the yields of representative securities, calculating gross investment revenues of China's foreign exchange reserves in terms of nominal US dollar, real US dollar (US dollar index) and nominal RMB; finally, taking into consideration the PBOC's sterilization costs and estimating roughly the net investment revenue of China's foreign exchange reserves.

Because of the limited information on the asset structure of China's foreign exchange reserves, we must make some assumptions to simplify the calculation process. First, since China's outward portfolio investment is highly concentrated in the hands of the PBOC, we assume that all US and Japanese securities that China holds belong to the PBOC's foreign exchange reserve assets, and the shares of dollar, euro and yen assets are presented by Figure 1. Second, considering that more than 90 percent of China's holding of US and Japanese government bonds are long-term debt securities, and the share of equity and corporate debt securities is negligible, we assume that the PBOC's holdings of Japanese and European securities are long-term government bonds, while China's US securities assets include short-term Treasury bills, long-term Treasury bonds, and long-term agency bonds. Third, according to the *Report on Foreign Portfolio Holdings of US Securities*, three-month and five-year US Treasury bonds are the main kinds of US government debt securities, therefore, we assume that the the interest rate of three-month, and five-year US Treasury securities is the representative yield of US short-term, and long-term government bonds respectively. Fourth, since the yields of US agency bonds are unavailable and 67 percent of US agency bonds are 20-year and 30-year terms, we hence use the 30-year US mortgage fixed rate to represent the interest rate of long-term US agency bond.

Based on the above assumptions, the investment revenue of China's foreign exchange reserves can be expressed as

$$R_t = \alpha_{u,t}\left(\sum_i \beta_{i,t}\, r^i_{u,t}\right) + \alpha_{e,t} r^*_{e,t} + \alpha_{j,t} r^*_{jt}$$

Where α_u, α_e and α_j is represented as the share of dollar, euro and yen assets in the total Chinese foreign reserves respectively, β_i is the share of US 5-year US Treasury bond, 3-month Treasury bonds and long term agency bonds (30-year mortgage) in the dollar assets of the PBOC respectively, and r_u^i is the interest rate of long-term US Treasury bonds (5-year), short-term US Treasury bonds (3-month), and long-term US agency bonds (30-year mortgage) correspondingly, r_e^*, and r_j^* is the yield of the PBOC's euro and yen assets denominated in US dollars respectively.

Table 5 presents the gross and net investment revenue of China's foreign exchange reserves in terms of US dollars and RMB. Over the period from 2002 to 2011, the yields of US dollar assets have shown a steadily declining trend. The US financial crisis and the Fed's quantitative easing monetary policy have produced significantly negative impacts on the yields of US dollar assets, which fell substantially from 5.28 percent in 2007 to 2.60 percent in 2010, and 1.98 percent in 2011. The yields of euro zone long-term Treasury bonds have remained relatively stable during this period, declining slightly from 4.36 percent in 2008 to 3.78 percent in 2010, and rising to 4.31 percent in 2011. This means that the positive effects of the European sovereign debt crisis on the yields of euro zone government debt securities had surpassed the negative effects of expansionary monetary policy over the period between 2009 and 2011. The yields of Japanese long-term government bonds remained low and showed an obvious downward trend over the past decade, decreasing from 1.45 percent in 2008 to 1.15 percent in 2010, and 1.12 percent in 2011.

Over the past decade, the exchange rates of the euro and yen versus the dollar have experienced substantial fluctuation, so the yields of euro and yen assets would display large variation if they were denominated in US dollars. As Table 5 shows, if denominated in US dollars, the average yield of euro and yen assets is 8.63 percent and 6.78 percent respectively during the period between 2002 and 2011, which is much higher than the yield of 4.1 percent for dollar assets. With the substantial appreciation of the Japanese yen versus the US dollar since the beginning of the financial crisis, the interest rate of Japanese long-term government debt securities denominated in US dollar reached 9.09 percent in 2010 and 8.24 percent in 2011 respectively. Following the European sovereign debt crisis and the large depreciation of the euro against the dollar, the yield of euro zone long-term government debt securities was -5.53 percent in 2010, and rose to 3.81 percent in 2011.

The impacts of the international financial crisis on the investment revenue of China's foreign exchange reserve are manifested through the mechanisms of interest rates and foreign exchange rates. A sharp rise in liquidity and credit risk in the private sector in the US, and the "flight to quality" effect can lead to a decrease in the yields on US government debt securities, while the European sovereign debt crisis can result in an increase in the yields on some euro zone government bonds and a decrease in others. A depreciation of the US dollar versus the euro and Japanese yen will cause an increase in the dollar-denominated yields of euro and yen assets, and hence the dollar yields of China's foreign exchange reserves will rise, while their real value will decrease. On the contrary, an appreciation of the US dollar will induce a decline in the dollar-denominated yields of euro or yen assets, and also a reduction in total yields on China's foreign exchange reserves, while the real value of China's exchange reserves will rise. Therefore, the rise or fall in

dollar-denominated yields of China's foreign exchange reserves doesn't necessarily imply that its real yields will rise or fall correspondingly. In order to evaluate the real dollar-denominated yields of China's foreign exchange reserves, it is necessary to investigate the indicator of real dollar value (dollar index) in addition to nominal dollars.

	Gross Yield						Gross Yield	Gross Yield	Net Yield
	(USD)	USD Assets (USD)	Euro Assets		JPY Assets		(USD Index)	(RMB)	(RMB)
			Euro	USD	JPY	USD			
2002	9.90	4.95	4.92	19.31	1.25	5.93	-0.43	9.91	8.94
2003	11.49	4.08	4.16	24.80	1.01	14.15	-3.67	11.48	9.45
2004	8.07	4.36	4.14	13.15	1.50	5.28	0.38	8.07	5.79
2005	0.09	4.72	3.44	-8.08	1.36	-11.01	11.49	-2.39	-4.37
2006	8.50	5.44	3.86	15.19	1.73	2.70	0.25	5.26	3.21
2007	8.75	5.28	4.33	14.59	1.65	5.98	0.83	2.59	0.21
2008	2.30	4.41	4.36	-2.84	1.45	24.65	10.50	-5.21	-7.78
2009	6.28	2.90	4.03	11.93	1.34	2.81	-1.30	5.90	4.40
2010	-0.12	2.60	3.78	-5.53	1.15	9.09	4.18	-2.80	-4.50
2011	3.19	1.98	4.31	3.81	1.12	8.24	2.57	-1.55	-3.02

Table 5. Gross and Net Yield of China's Foreign Exchange Reserves (Percent). *Source:* CEIC and Authors' Calculation.

According to Table 5, the gross dollar-denominated yield of China's foreign exchange reserves has declined in the past decade, falling significantly from 7.80 percent over the period between 2002 and 2008 to 2.91 percent following the financial crisis. Although the yield of dollar assets decreased from 4.41 percent in 2008 to 2.90 percent in 2009, the dollar-denominated yield of China's foreign exchange reserves grew from 2.30 percent to 6.28 percent, due to the substantial appreciation of the euro versus the US dollar in 2009. In 2010, the dollar-denominated yield of China's foreign exchange reserves fell to its historically lowest level of -0.12 percent, which can be attributed to the appreciation of 9.31 percent of the US dollar against the euro in that year, even though the yen also recorded a large appreciation versus the dollar.

In terms of the dollar index (real dollar), the average gross yield of China's foreign exchange reserves was 2.48 percent over the period between 2002 and 2008, which is significantly lower than the 5.85 percent yield on the basis of nominal dollars. The average yearly depreciation rate of the dollar is 3.37 percent in this period. This means that for China the exchange rate risk of the dollar is huge, constituting a serious threat to the security of China's foreign exchange reserves. However, the depreciation trend of the dollar has been reversed since the financial crisis began, due to "flight to quality" effect and the rise in dollar demand. The average real-dollar-denominated yield of China's foreign exchange reserves is 3.99 percent since 2008, much higher than 2.91 percent yield in nominal dollar terms, and hence the average yearly appreciation rate of the dollar is around 1 percent. Nevertheless, it is highly possible that the dollar will depreciate again once the advanced economies restore normality or a new round quantitative easing measures is adopted in the US. During the financial crisis, the exchange rate of the dollar has fluctuated largely, leading to substantial variations in the real-dollar-denominated yields of China's foreign exchange reserves, which rose sharply from 0.83 percent in 2007 to 10.5 percent in 2008, and fell rapidly to -1.30 percent the following year.

If denominated in RMB, the gross investment yield of China's foreign exchange reserves has remained low, even recording a negative yield in some years since the reform of the RMB regime in 2005, and the average RMB yield was only 0.26 percent during the period between 2005 and 2011. China's foreign reserves suffered investment losses in 2008, 2010 and 2011, with yields of -5.21 percent, -2.80 percent and -1.55 percent respectively, which can be attributed to the large appreciation of RMB against the dollar and the low dollar-denominated investment yields. Obviously, the low or even negative investment yield of China's foreign reserve has constituted a serious threat to the balance sheet of China's monetary authority.

If high sterilization costs are taken into account, it is a formidable task for China's monetary authority to break even on costs and benefits of its foreign reserve holdings. Before the reform of RMB exchange rate regime in 2005, it was possible to achieve an average net yield of 8.06 percent between 2002 and 2004 on China's foreign exchange reserves, but after the reform of the RMB regime, the net investment yield has deteriorated rapidly, with the average net yield of -1.69 percent over the period from 2005 to 2011. China's foreign reserves have recorded negative net investment yields in many years since 2005, such as, in 2005, 2008, 2010 and 2011, when the net yield was -4.37 percent, -7.78 percent, -4.50 percent and -3.02 percent respectively. The international financial crisis has brought about negative effects on the net investment income of China's foreign reserves due to the induced sharp decline in the yields of US government debt securities, with the net yield in RMB terms declining quickly from 3.21 percent in 2006 to -2.73 percent over the period between 2008 and 2011.

According to Table 5, an interesting phenomenon is that the net investment yield in RMB terms of China's foreign reserves was substantially improved in 2009, rising from -7.78 percent in 2008 to 4.4 percent in 2009. This may be attributed to three main factors: first, the large depreciation of the dollar versus the euro, hence the significant rise in the dollar-denominated yield of China's foreign reserves; second, the RMB returned to a peg against the dollar temporarily, hence the rise of dollar-denominated yield directly led to an equivalent increase of RMB-denominated yield; third, the sterilization cost decreased

largely due to the marked decline in the interest rates in China's domestic capital market and the PBOC turning to the cheap sterilization instrument of statutory reserve requirement ratios. Nevertheless, despite the respite this brought, the huge fiscal cost that China is paying or will pay will unavoidably ruin the balance sheet of the monetary authorities and reduce monetary autonomy, and hence undermine the stability of the Chinese economy.

5. Conclusion and Policy Implications

The recent international financial and sovereign debt crises have unleashed sovereign default risk in some euro zone members and the US. Such an outcome would trigger large capital losses for China's foreign exchange reserves. According to our calculation by rule of thumb, the optimal size of China's foreign reserve was a record USD 1.547 trillion in 2011, but the amount of its excess international reserves also skyrocketed to USD 1.634 trillion. Hence, how to invest the huge excess international reserves has became the most challenging task that China's monetary authorities face.

Currently, China's foreign exchange reserves are mainly invested in US, European and Japanese long-term government and agency debt securities. The international financial and sovereign debt crises have accelerated the diversification of China's foreign exchange reserves, with a substantial decline in US agency securities holdings and a significant increase in purchases of Japanese government bonds. Although the PBOC's sterilization costs are generally in control at the price of financial repression and economic structure distortion, it has become an increasingly difficult task for the central bank to realize a break even on the costs and benefits of holding foreign reserves since the financial crisis began, due to the historically low international interest rates originating from quantitative easing monetary policies in advanced countries intended to address global economic recession, and also exchange rate movements.

Since the vast majority of China's foreign reserve assets are high-rated government debt securities, the financial crisis and European sovereign debt crisis have not caused large capital losses. In fact, China has gained some short-run unforeseen profits from its massive investments in US government debt, resulting from the significant rise in market prices of US Treasury securities. During the sovereign debt crisis, China has recorded some losses on its investment in euro assets owing to the depreciation of the euro, but the impacts of the default on euro debt securities and even the restructuring of Greek debt have been limited to private holders and have not affected the Chinese government. However, when the global economy, financial system and government fiscal positions return to normal, the mismatch in the risk and return on China's foreign reserves will deteriorate, with long-term fixed income securities as the main investment targets. At present, China's foreign exchange reserves face three potential risks: default risk on US agency bonds and government debt securities in some euro zone peripheral members; inflation and interest rate risk originating from the quantitative easing monetary policies in the US; foreign exchange rate risk owing to the long-term depreciation of the US dollar.

Given the background of US financial crisis and European sovereign debt crisis, China should adjust its international reserve management principles and objectives, and give investment return a much higher priority while emphasizing liquidity and security. To

fundamentally change the mismatch between risk and return, China should accelerate the diversification of its international reserves. The policy suggestions are as follows:

First, reform China's current international reserves management system, and establish a new system co-regulated by the Ministry of Finance and the PBOC. The Ministry of Finance would take charge of formulating international reserve investment strategy, and the PBOC would be responsible for foreign exchange market intervention and prudent management of foreign exchange reserves. China's foreign exchange reserves should be divided into a liquidity portfolio and an investment portfolio, the liquidity portfolio being invested in highly liquid and rated government debt securities of developed countries, and the investment portfolio being mainly invested in enterprise debt and equity securities. Sovereign wealth funds under the Ministry of Finance would be responsible for investment of the investment portfolio, while the State Administration of Foreign Exchange under the PBOC would be in charge of management of the liquidity portfolio.

Second, China could use outward investment to recycle its excess foreign exchange reserves. Chinese companies could take advantage of investment opportunities outside China to engage in outward investment in order to help diversify the use of foreign exchange reserves and perhaps achieve a better return. China's outward investment, while it has grown rapidly in recent years, remains small relative to the size of its economy. Many Chinese companies are weak in terms of resources, technology and know-how, distribution channels and brands required to compete on a global stage and are likely to increase their outward investment in the future in order to make up for such weaknesses. It would be possible for the PBOC to collaborate with commercial banks to provide loans to Chinese enterprises in support of outward investment. However, such investments are not without risk. Given the lack of experience of most Chinese companies in managing transnational business, and also ongoing economic difficulties in many target locations originating from the financial and the sovereign debt crises, especially in the developed world, without adequate controls such a strategy may face significant risks with no guarantee that there would be better returns on investment.

Third, the process of diversification from US dollar assets should be continued, with a moderate fall in the dollar assets and a relative increase in euro assets. Although China has suffered some capital loss on euro assets in recent years, the sovereign debt crisis has been ameliorated due to the policy intervention by the European Central Bank (ECB), fiscal packages in member states, and restructuring of Greek debt securities. The value of the euro has also experienced significant downward adjustment, hence, it may be an appropriate time for China to increase purchases of European sovereign debt securities. The yen has substantially appreciated since the US financial crisis, and as the possibility of yen depreciation has risen substantially, so the risk for China in increasing its holdings of JGBs has also increased.

Fourth, China could gradually increase its holdings of gold reserves. Gold is an effective hedge for international reserves. At present, the US's gold reserve amounts to 7400 tons, accounting for 76 percent of its international reserves, and the share of gold in the reserves of Germany, France, and Italy is also more than 60 percent, while that of the PBOC is only 1.7 percent. Despite the fact that the current gold price is at a record high, it still has some room to rise if Fed's quantitative easing monetary policy continues. China should learn

from the experience of the US and Europe, and gradually increase its holding of gold reserves.

Finally, to substantially reduce the share of foreign exchange reserves in foreign assets, China should take effective measures to curb the growth momentum of China's foreign exchange reserves, gradually remove the restrictions on holding foreign assets by households and enterprises in China, relax the controls of cross-border capital movement, and encourage domestic enterprises to carry out overseas direct investment and portfolio investment.

Notes and References

[1] Compared to its large international reserves, the factor of capital controls is possibly a much more important contributive factor to the stability of China's cross-border capital flows. Even so, the accumulation of foreign reserves can significantly enhance investors' confidence in the smooth operation of China's restrictive regulation of capital movements.

[2] Wijnholds, J. Onno de Beaufort and Arend Kapteyn, 2001. Reserve Adequacy in Emerging Market Economies, IMF Working Paper, September 2001.

[3] IMF, 2011. Assessing Reserve Adequacy, Monetary and Capital Markets, Research, and Strategy, Policy, and Review Departments, February 14, 2011.

[4] There is evidence that reserve managers' investment behavior during the crisis was procyclical. In particular, when the crisis struck, deposits from commercial banks were withdrawn, euro zone covered bonds were sold, and US agency debt was sold or put back. According to an estimate by the IMF, central bank reserve managers withdrew over USD 500 billion from the global banking sector during the crisis. This withdrawal coincided with the collapse of the interbank funding market, so that banks were forced to rely largely on funding from a few reserve currency issuing central banks. Lipsky John, 2011. Financial Crisis and Reserve Management: Outlook for the Future, International Monetary Fund, January 24, 2011.

[5] Bertaut, Carol, William Griever, and Ralph Tryon, 2006. Understanding US Cross-Border Securities Data, *Federal Reserve Bulletin*, 2006, pp.59-75.